FINAL REPORT

INTRODUCTION AND DEVELOPMENT OF ALTERNATIVE FORAGE GRASS SPECIES AND CULTIVARS

19960288

March 2001

Prepared by: Agriculture & Agri-Food Canada

AGRI-FOOD INNOVATION FUND

Canada

Saskatchewan

101-04706/

CANADA-SASKATCHEWAN

AGRI-FOOD INNOVATION AGREEMENT

Project 96000288

Introduction and Development of Alternative Forage Grass Species and Cultivars

Final Report

March, 2001

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(a) Summary

There is increasing interest in Saskatchewan in forage grasses as a feed source for an expanding beef industry. Annual ryegrasses have shown promise for providing summer and fall grazing, particularly in the Parkland. This study demonstrated that these ryegrasses are amongst the highest yielding grass species available and identified high yielding cultivars. Selection for new lines that maintain greenness later in the fall produced higher quality lines with similar yields to standard cultivars. Perennial ryegrass is being increasingly grown for seed destined for the export market. This study examined the cold hardiness of perennial ryegrass cultivars seeded at various dates in spring, late summer and fall. Seedings done in early to mid-August achieved the greatest level of cold tolerance. Crested wheatgrass has been the standard hay and pasture species for drier regions of Saskatchewan. This study evaluated a number of new tetraploid crested wheats and led to the selection of a high yielding, high quality line, and a late maturing line that may maintain its quality longer into the summer. Hybrids between smooth and meadow bromegrass have shown potential as a dual purpose hay/pasture species for the prairies. In this study, crosses were made between these two species and a new hybrid line selected, which is expected to be more widely adapted than previous hybrid lines. All of the new lines selected in this study will be entered in local and regional evaluation trials. If performance is good, they will be released between 2004 and 2007, depending on the species.

(b) Technical Report

1. Background and Objectives:

Westerwolds and Italian ryegrasses have shown potential for fall and early winter grazing in preliminary trials, which represents a method of reducing feeding costs for those backgrounding beef cattle. There is a need to introduce and evaluate ryegrass cultivars and also to select new cultivars which will be high yielding and grow later in the fall under our cool climatic conditions. There is also a possibility that seed of these ryegrasses, and also perennial ryegrasses, could be produced in Saskatchewan, lessening our dependence on foreign seed supplies and possibly creating export opportunities. Cultivars of annual and perennial ryegrass must be evaluated for their seed production capabilities in Saskatchewan. Cultivars of perennial ryegrass vary widely in cold tolerance and this must be evaluated to recommend the best cultivars to Saskatchewan producers.

Crested wheatgrass, an important pasture grass in the brown and dark brown soil, loses its quality and palatability rapidly as the plant matures. Thus, there is a need to produce later maturing cultivars that do not lose quality as rapidly, to provide better summer grazing. In addition, tetraploid *A. cristatum* types have proven to be more vigourous and higher yielding than the diploid *A. cristatum* and tetraploid *A. desertorum* cultivars. There are a number of new germplasm sources of the tetraploid *A. cristatum* which need to be evaluated and selected under Saskatchewan conditions.

Hybrids between smooth and meadow bromegrass have shown promise as dual purpose hay-pasture species. The first cultivar was released in February, 2000. Hay yields in the black/grey wooded zones of Saskatchewan and Manitoba have been somewhat lower than smooth bromegrass, so there is a need to generate a new series of hybrid lines, using smooth bromegrass parents that are better adapted to these zones.

This project will develop and/or assess new forage grass species (*Lolium* ryegrasses) and new cultivars and types of traditional species (crested wheatgrass and bromegrasses) to reduce costs of beef production and provide additional cropping choices to forage and seed producers. This corresponds to the needs of the Strategic Committee for Specialized Crops "to develop adapted, high quality specialized crop varieties through cultivar selection and plant breeding". The introduction and development of these new species/cultivars will increase the acreage of forage grasses grown for seed and forage in crop rotations. This is an agronomic strategy to break disease and weed cycles in annual crops thus meeting the other Committee need "to develop environmentally acceptable and cost efficient pest control methods and agronomic strategies".

2. Project activities, achievements, papers written:

i) Westerwolds and Italian ryegrass forage production

Between 1996 and 2000, a number of cultivars of Italian and Westerwolds ryegrasses were tested for forage production, with and without companion crops, at Melfort. Most of these cultivars originated from Europe. Companion crop treatments were wheat - 80 and 40 kg/ha, and barley - 70 and 35 kg/ha. With no companion crop, two forage harvests were taken (mid-August and late-October). The companion crops were harvested for grain in late-August and the regrowth of the ryegrass was harvested for forage in mid-October.

ii). Selection of ryegrass cultivars with superior fall growth

Spaced-planted nurseries of several cultivars of Italian and westerwolds ryegrasses (40 plants of each) were established in the springs of 1997, 1998, 1999 and 2000. In the summer of each year, plants were scored for vigor and cut back. In late October of each year, the regrowth of each plant was scored for vigor and greenness. Superior plants were selected and brought into the growth cabinets at the Saskatoon Research Centre for interpollination to produce new experimental synthetics lines. The following new lines were developed:

Year	Type	Experimental designation	No. of selected plants
1997	Westerwolds	S9463	19
1997	Italian	S9464	49
1998	Italian	S9458	13
1998	Westerwolds	S9459	21
1999	Westerwolds	S9479	24
1999	Italian	S9480	24
2000	Westerwolds	S9486	30
2000	Italian	S9487	31

Seed of these new lines was planted in sward density evaluation trials at Saskatoon in 1999 and 2000 and at Melfort in 2000. Forage harvests were taken twice in each year (early August and late September). Seed of the 2000 selections will be planted at Saskatoon and Melfort in 2001.

Seed of S9459 was planted in an isolated area of the Saskatoon research farm in for seed increase in the spring of 1999. The same was done for S9479 in 2000. Seed of S9458 was dormant seeded for seed increase in the fall of 1999. A small amount of seed was harvested from S9459 and S9479. S9458 failed to emerge in the spring of 2000, so no seed was harvested. These poor seed increases made it impossible to seed larger scale trials at Melfort.

iii). Cold hardiness of perennial ryegrass cultivars

In 1998, Norlea and Catalina perennial ryegrasses were planted at Outlook (irrigated) and Melfort (rainfed) at five different dates in 1998: May 10, August 1, August 15, August 30 and September 15. Plants of both cultivars from each of these seedings at Outlook were dug and brought into the lab on October 19 and November 6, planted in root trainers, stored overnight at -4, and subjected to freezing tests in a specialized freezer at the Crop Development Centre of the University of Saskatchewan. Half of the plants sampled on November 6 were stored at -2 until December 15, to test the longevity of hardiness. These plants were successively subjected to temperatures of -3, -5, -7, -9, -11, and -13 for one hour. After exposures to each temperature a number of plants of each treatment were removed and placed in the greenhouse. After four weeks the number of surviving plants were counted and the plant material was weighed. LT 50's were calculated as the temperature at which 50% of the plants were killed.

In 1999, Norlea and Catalina perennial ryegrasses were planted at Outlook (irrigated) at five different dates in 1998: June 7, August 5, August 16, August 30 and September 13. Plants of the two cultivars from each of these seedings were dug and brought into the lab on November 2 and 17, planted in root trainers, stored overnight at -4 and subjected to freezing tests in a specialized freezer at the Crop Development Centre of the University of Saskatchewan. The plants sampled on November 17 were stored at -2 until December 15, to test the longevity of hardiness. These plants were successively subjected to temperatures of -3, -5, -7, -9, -11, and -13 for one hour. After exposures to each temperature a number of plants of each treatment were removed and placed in the greenhouse. After four weeks the number of surviving plants were counted and the plant material was weighed. LT 50's were calculated as the temperature at which 50% of the plants were killed.

iv). Evaluation and selection of new tetraploid crested wheats

Nursery (spaced-planted) established in 1997: This nursery included selections and open-pollinated crosses of the tetraploid crested wheatgrass lines Kirk (the most widely grown crested wheat), Hycrest (a hybrid from Utah) and S-9240 (a tall, large seeded line). In 1999, these were harvested (twice) for forage yield and in 2000 for seed yield. Individual plants were scored for vigor and rated for maturity at various times from 1998-2000, and were sampled at full heading in 2000 and analyzed for forage quality (CP, ADF, and NDF).

Nursery (spaced-planted) established in 1998: This nursery included additional crosses made

between selected plants of S-9240 and Kirk in 1997. In 1999, these were harvested (twice) for forage yield and in 2000 for seed yield. Individual plants were scored for vigor and rated for maturity at various times from 1999-2000, and were sampled at full heading in 1999 and 2000 and analyzed for forage quality (CP, ADF, and NDF).

In the fall of 2000 plants were selected on the basis of vigor, maturity ratings from lines that had high forage and seed yield and high forage quality. Selected plants were brought into the greenhouse and interpollinated to produce two new experimental synthetic lines:

Exp. Designation	SelectionCriteria	No. of plants selected
S9489	Vigor, high yield and quality	38
S9490	Later maturity	19

These lines will be seeded in sward density evaluation trials at Saskatoon in 2001.

v). Production of new hybrid brome line

Crosses between plants of Fleet meadow bromegrass and Radisson, Rebound and Baylor smooth bromegrass were carried out in the greenhouse over the winter of 1997-98. Close to 200 putative hybrid plants from 42 different crosses were established in spaced-planted nurseries in 1998. This nursery was evaluated for morphological characters, seed yield and RAPD markers in 1999. This evaluation was carried out to identify plants that were truly hybrid and not resulting from self-pollination. Approximately 100 hybrid plants were identified and 32 of these, from a range of different crosses were selected. These were brought into the greenhouse in late fall, 1999 and interpollinated to produce a new experimental synthetic line (S9478). This was seeded in a sward density evaluation trial and established in spaced-planted selections nurseries at Saskatoon in 2000.

Papers:

Coulman, Bruce and Heather Loeppky. 1998. The potential of *Lolium* ryegrasses as seed and forage crops in western Canada. Proceedings of the Soils and Crops Workshop. University of Saskatchewan. February 19, 20.

Coulman, Bruce and Heather Loeppky. 1999. Lolium ryegrass seed production research: Summary 1996-98. Proceedings the Manitoba Forage Seed Association Meeting. Winnipeg, January 24-27.

Coulman, Bruce , Heather Loeppky, and Linden MacFarlane. 2000. Ryegrass seed production in western Canada. Proc. 2000 Canadian Alfalfa and Forage Seed Conference. Edmonton. Forage Seed News 7: 71-74.

Mellish, A. and B. Coulman. 2000. Morphological analysis of S9240 tetraploid crested wheatgrass (*Agropyron cristatum*). Proc. Soils and Crops Workshop. University of Saskatchewan.

Coulman, B. 2000. Introduction and development of alternative forage grass species and cultivars. Proc. AFIF Conference, Regina, November.

3. Results and conclusions

i) Westerwolds and Italian ryegrass forage production

When ryegrasses were planted with no companion crop, two cuts were taken (mid-August and late October) and mean total annual forage yields were around 12 t/ha (Tables 1 and 2). Yields were highly variable from year to year, reflecting differences in amounts of rainfall; however, even in 1999, the driest year, yields ranged from 5-8 t/ha. There was little difference in mean yield between Italian and westerwolds ryegrass. Among Italian ryegrass cultivars (Table 3), there were four that outyielded Maris Ledger, the standard cultivar which has been grown on the prairies. For westerwolds ryegrass (Table 4), seven cultivars outyielded the standard cultivar Aubade.

When companion crops were used (Tables 1 and 2), ryegrass fall forage yields were considerably reduced. Wheat and barley were equally competitive with the mean yield reduction, relative to no companion crop, being about two-thirds for the high seeding rate and one-half for the low seeding rate. Mean fall yields were about 3 t/ha for Italian and 2 t/ha for westerwolds under low seeding rate companion wheat or barley. Again, yields were highly variable by year, with greater than 6 t/ha produced by Italian ryegrass under wheat in 1996. In years with dry falls, such as 1998, wheat was more suppressive than barley, while in moister years, such as 1996, the opposite was true.

ii). Selection of ryegrass cultivars with superior fall growth

At Saskatoon in 1999 (Table 5), S9463 and S9459 westerworlds ryegrasses, selected for late fall growth, were lower yielding than Aubade. These lines were found to be much later maturing than Aubade, which would improve quality, but result in lower yields when cut at the same time. S9463 and S9459 also held their greenness much better than Aubade in the fall. S9458 Italian ryegrass was higher in yield, and similar in fall greenness, to Maris Ledger. In 2000 at Saskatoon (Table 6), S9463 was slightly higher yielding, and S9479 and S9459 slightly lower yielding than Aubade. At Melfort (Table 7), Both S9479 and S9459 outyielded Aubade. S9480 was slightly lower yielding than Aubade at Saskatoon.

For forage quality (Table 8), S9480 was similar in protein and fiber to Maris Ledger. All of the selected westerwold ryegrass lines were considerably higher in protein and lower in fiber than Aubade.

iii). Cold hardiness of perennial ryegrass cultivars

In the 1998 cold hardiness trials (Table 9), the Aug 30 and Sept 15 seedings were the least hardy in the Oct. 19 sampling with LT50's from -9 to -11, compared to -13 for other seedings. By the Nov 6 sampling, hardiness had increased so that Lt50s were at temperatures colder than -13 for most seeding dates, the exception being Sept. 15. Storing the plants until Dec. 15 did not change the LT50 except for the Sept. 15 seeding of Catalina. This latter seeding date produced the least hardy plants for all samplings, likely due to the immaturity of the seedlings. The Aug 30 seedings were also somewhat less hardy than earlier seedings, particularly at the Oct. 19 sampling. The hardiness of Norlea and Catalina were similar, with Catalina showing poorer survival only for the Sept. 15 seeding.

In the 1999 cold hardiness trials (Table 10), at the Nov 2 sampling date for Norlea, the spring, Aug 30 and Sept 13 seedings were the least hardy with LT50's from -5 to -9, compared to lower than -13 for Aug. 5 and 16. For Catalina, the only seeding date which showed poor winter hardiness was Sept 15. By the Nov 17 sampling, hardiness had increased so that Lt50s were at temperatures colder than -13 for almost all seeding dates. When plants sampled on Nov. 17 were stored at -2° until Dec. 17, the spring and later summer seeding dates showed a considerable reduction in hardiness, likely due to respiration and dessication. The results were quite similar to those of 1998, with the later seeding dates being the least hardy, likely due to the immaturity of the seedlings. The spring seedings also showed some tendency to be less hardy than those of early to mid August, perhaps due to excessive growth.

iv). Evaluation and selection of new tetraploid crested wheats

For the KirkXS9240 nursery established in 1998, several lines produced numerically higher hay yields than Kirk and S9240J in 1999 (Table 11). For seed yield (Table 12), a few lines were also numerically higher yielding than Kirk and S9240J in 2000. Several lines were also much taller than these two parental lines, indicating hybid vigor for this character. In forage quality (Tables 13 and 14), many lines showed higher protein and lower fiber than Kirk or S9240J.

For the nursery established in 1997, containing lines from outcrosses among Kirk, S9240, and Hycrest, there was only one line numerically higher than Kirk in forage yield (Table 15). For seed yield, two lines significantly outyielded Kirk in 2000 (Table 16), while there was little difference in height among lines. Several lines also showed higher protein percentages than Kirk in 2000 (Table 17).

v). Production of new hybrid brome line:

A new hybrid line (S9478) was produced by crossing, progeny evaluation and interpollination of selected plants (described above). The first performance data will be collected from this line in 2001.

4) Indications for further development:

Forage yields of Italian and westerwolds ryegrasses found in this study at Melfort, indicate that these grasses are probably the highest yielding grasses that can be grown in this region. Several cultivars of both westerwolds and Italian ryegrass outyielded the most commonly grown ryegrasses in western Canada. Although there is some present use of these ryegrasses, more livestock producers in the Parkland area should seriously consider these ryegrasses in their forage plan.

New selections of westerwold ryegrass produced similar forage yields to the standard cultivar Aubade, but had superior forage quality and maintained greenness into the fall. These lines will be entered in regional trials in western Canada, as soon as sufficient seed is available.

Seeding of perennial ryegrass in early-mid August resulted in plants that were capable of achieving a reasonably high level of hardiness going into the winter. Later seedings resulted in plants that were considerably less hardy, while spring seeded plants also showed a tendency to not be as hardy as those sown in early to mid-August. August seedings may not establish well on dryland, as this is the driest part of the growing season; however, under irrigation, this would be the optimum time to seed. These results are of interest to producers who would like to produce perennial ryegrass seed for the export market.

Crested wheatgrass lines have been selected which have the potential to be superior in forage yield and quality to presently grown cultivars. Evaluation in sward-density trials will be carried out to verify this.

A new meadow X smooth bromegrass hybrid has been synthesized using southern ecotype smooth bromegrasses in the cross. It will be evaluated in forage trials to determine its agronomic worth and adaptation.

5. Diversification and impact on production/producers/marketplace:

Although the lines produced in this study need to be further evaluated before being released to producers, they have the potential to aid in crop diversification and provide important forage resources for increasing number of beef cattle and specialty livestock. The new high quality ryegrass lines can provide high quality pasture, particularly in the summer and fall. The cold tolerance work on perennial ryegrass provides important information of seeding time for producers wanting to produce seed of this species as part of a crop diversification program. New lines of crested wheatgrass will provide higher yielding cultivars, and the later maturing line may hold its quality better into the summer period. The new hybrid brome line has the potential to provide a widely adapated dual purpose hay/pasture species for the livestock industries.

d) Equipment
No equipment was purchased during the project

e) Project photos
None submitted

f) Innovation Fund Acknowledgement
Made in presentation at the Canadian Forage and Turfseed Conference (2000 and 2001), the Soils and Crops Workshop (1998 and 2000) and the Manitoba Forage Seed Association Meeting (1999). Acknowledgement was also made in the publications coming from these meetings.

g) Project Public Information Materials
None

i) Deliverables for Evaluation

2000-01:

- Continue larger scale evaluation of promising ryegrasses (on farm), continue evaluation of ryegrass for forage production (Melfort)
- Increase seed of selected ryegrass lines (Saskatoon)
- Increase seed of selected crested wheatgrass lines (Saskatoon)
- Screen and select new brome hybrid lines (Saskatoon)

All of these milestones were met as described in the **b) Technical Report** above. The exception was that there was no on farm seeding of ryegrass at Melfort due to lack of seed of the selected lines.

Overall:

i) Breeding goal of 5% improvement in quality and/or yield - For the ryegrass selections, this appears to have been accomplished, especially for forage quality. Selected crested wheatgrass plants also showed at least this level of improvement, but evaluation of newly synthesized lines will have to be carried out to verify this advantage. The advantages of the newly synthesized hybrid brome line will also have to be verified by evaluation trials.

ii) Cultivar releases by 2006 - For the westerwolds ryegrass, providing we can produce enough seed, entries can be made into the Western Forage Testing System (WFTest) in 2002. Ryegrasses are tested for two years in this system, so a release could be made as early as 2004. For the crested wheats and hybrid brome, evaluation will be carried out at Saskatoon in 2001 and 2002. If promising, these lines will be entered into the WFTest in 2003, and evaluation carried out 2004-2006. New lines could be released in 2007.

iii) Agronomic information - Data on yield of ryegrass cultivars will be combined with results from Sask. Forage Council trials and will be published in the Sask. Forage Crop Production Guide.

Table 1. Italian ryegrass variety trial forage production (kg/ha) by companion crop at Melfort 1996-1998

variety	Companion Crop	1996 Fall yield	1996 total yield	1997 Fall yield	1997 total yield	1998 Fall yield	1998 total yield	1996-98 Mean Fall Yield	Mean Tot Yield
Bartissimo	no companion	9458	14150	4716	11428	1557	6491	5244	10690
	wheat 80 kg/ha	3487	3487	1470	1470	61	61	1673	1673
	wheat 40 kg/ha	5890	5890	2409	2409	558	558	2952	2952
	barley 70 kg/ha	2517	2517	1537	1537	963	963	1672	1672
	barley 35 kg/ha	3357	3357	2712	2712	1588	1588	2552	2552
Barverdi	no companion	9245	14531	4224	10136	2515	10669	5328	11779
	wheat 80 kg/ha	3937	3937	1355	1355	48	48	1780	1780
	wheat 40 kg/ha	5250	5250	2566	2566	680	680	2832	2832
	barley 70 kg/ha	2589	2589	1722	1722	772	772	1694	1694
	barley 35 kg/ha	3925	3925	2751	2751	1073	1073	2583	2583
Bartolini	no companion	9639	15826	5281	12278	1946	10501	5622	12868
	wheat 80 kg/ha	2759	2759	1162	1162	166	166	1362	1362
	wheat 40 kg/ha	5478	5478	2842	2842	366	366	2895	2895
	barley 70 kg/ha	2649	2649	1726	1726	663	663	1679	1679
	barley 35 kg/ha	3281	3281	2904	2904	1460	1460	2548	2548
Bartali	no companion	9543	15625	6321	12334	1896	8937	5920	12299
	wheat 80 kg/ha	4319	4319	1190	1190	245	245	1918	1918
	wheat 40 kg/ha	5889	5889	2153	2153	754	754	2932	2932
	barley 70 kg/ha	2773	2773	1926	1926	873	873	1857	1857
	barley 35 kg/ha	4727	4727	3472	3472	1582	1582	3260	3260
Barmultra	no companion	10300	16792	5418	12165	3191	11320	6303	13426
	wheat 80 kg/ha	4657	4657	1553	1553	189	189	2133	2133
	wheat 40 kg/ha	6008	6008	2430	2430	1159	1159	3199	3199
	barley 70 kg/ha	3991	3991	2259	2259	1550	1550	2600	2600
	barley 35 kg/ha	4641	4641	3427	3427	1758	1758	3275	3275
Barzini	no companion	9521	15553	4853	10165	2059	10180	5478	11966
	wheat 80 kg/ha	4080	4080	897	897	269	269	1749	1749
	wheat 40 kg/ha	5689	5689	1856	1856	621	621	2722	2722
	barley 70 kg/ha	2290	2290	2641	2641	1111	1111	2014	2014
	barley 35 kg/ha	4074	4074	3039	3039	1900	1900	3004	3004
Sabalan	no companion	10221	16950	5572	12110	2155	9576	5983	12879
	wheat 80 kg/ha	3959	3959	1111	1111	212	212	1761	1761
	wheat 40 kg/ha	5642	5642	2227	2227	548	548	2806	2806
	barley 70 kg/ha	2549	2549	1566	1566	1050	1050	1722	1722
	barley 35 kg/ha	3560	3560	3002	3002	2162	2162	2908	2908
Lemtal	no companion	8992	16100	5844	11530	1719	7697	5518	11776
	wheat 80 kg/ha	4186	4186	1034	1034	129	129	1783	1783
	wheat 40 kg/ha	5996	5996	2188	2188	844	844	3009	3009
	barley 70 kg/ha	2684	2684	1181	1181	746	746	1537	1537
	barley 35 kg/ha	3343	3343	2873	2873	1642	1642	2619	2619
Maris Ledger	no companion	7933	14252	6026	11892	1959	8074	5306	11406
	wheat 80 kg/ha	4674	4674	999	999	186	186	1953	1953
	wheat 40 kg/ha	6369	6369	3018	3018	426	426	3271	3271
	barley 70 kg/ha	2347	2347	1314	1314	196	196	1286	1286
	barley 35 kg/ha	3331	3331	3421	3421	1648	1648	2800	2800
c.v.		28.4	n/a	42.9	n/a	56.4	53.9		
lsd		n/a	n/a	n/a	n/a	---	---		

Means of Companion Crop Treatments - 1996-98

	Fall Yield	% no comp.	Total Yield
No Companion Crop	5633	100	12121
Wheat - 80 kg/ha	1790	32	1790
Wheat - 40 kg/ha	2958	53	2958
Barley - 70 kg/ha	1785	32	1785
Barley - 35 kg/ha	2839	50	2839

Table 2. Westerwolds ryegrass variety trial forage production (kg/ha) by companion crop 1996-99

Variety	Comp. Crop	1996 Fall yield	1996 total yield	1997 Fall yield	1997 total yield	1998 Fall yield	1998 total yield	96-98 Mean Fall Yield	96-98 Mean Total Yield
Agraco	no companion	9119	17755	2850	10121	1362	8176	4444	12017
Agraco	wheat 80 kg/ha	2934	2934	1563	1563	314	314	1604	1604
Agraco	wheat 40 kg/ha	3118	3118	2333	2333	502	502	1984	1984
Agraco	barley 70 kg/ha	2468	2468	2260	2260	643	643	1790	1790
Agraco	barley 35 kg/ha	2801	2801	2855	2855	928	928	2195	2195
Barspectra	no companion	9107	15959	3423	11095	2076	10387	4869	12480
Barspectra	wheat 80 kg/ha	2617	2617	1898	1898	514	514	1676	1676
Barspectra	wheat 40 kg/ha	3000	3000	3280	3280	874	874	2385	2385
Barspectra	barley 70 kg/ha	2225	2225	2323	2323	536	536	1695	1695
Barspectra	barley 35 kg/ha	2840	2840	3320	3320	1473	1473	2544	2544
Barwoltra	no companion	9276	16690	2961	11012	2120	10642	4786	12781
Barwoltra	wheat 80 kg/ha	2913	2913	1475	1475	306	306	1565	1565
Barwoltra	wheat 40 kg/ha	2877	2877	2340	2340	601	601	1939	1939
Barwoltra	barley 70 kg/ha	1961	1961	2160	2160	543	543	1555	1555
Barwoltra	barley 35 kg/ha	2354	2354	3217	3217	1084	1084	2218	2218
SW WWR9016	no companion	8119	15757	3163	9058	2072	10471	4451	11762
SW WWR9016	wheat 80 kg/ha	2605	2605	1315	1315	758	758	1559	1559
SW WWR9016	wheat 40 kg/ha	3567	3567	2251	2251	824	824	2214	2214
SW WWR9016	barley 70 kg/ha	2121	2121	2388	2388	565	565	1691	1691
SW WWR9016	barley 35 kg/ha	2670	2670	3236	3236	1238	1238	2381	2381
Aubade	no companion	7075	15290	2652	8832	1589	9755	3772	11292
Aubade	wheat 80 kg/ha	2118	2118	1367	1367	306	306	1264	1264
Aubade	wheat 40 kg/ha	2433	2433	2544	2544	370	370	1782	1782
Aubade	barley 70 kg/ha	1754	1754	2036	2036	586	586	1459	1459
Aubade	barley 35 kg/ha	1958	1958	2897	2897	882	882	1912	1912
c.v.		25.2	n/a	n/a	n/a	56.6	50.3		
lsd		532	n/a	—	—	—	—		

Means of Companion Crop Treatments Over All Varieties - 1996-98

	Fall Yield	% No comp.	Total Yield
No Companion Crop	4464	100	12067
Wheat - 80 kg/ha	1534	34	1534
Wheat - 40 kg/ha	2061	46	2061
Barley - 70 kg/ha	1638	37	1638
Barley - 35 kg/ha	2250	50	2250

Table 3. Italian ryegrass variety trial total (of 2 cuts) forage production (kg/ha) at Melfort 1996-2000

variety	1996 yield	1997 yield	1998 yield	1999 yield	2000 yield	96-2000 Mean yield	% M. Ledger
Barmultra	16792	12165	11320	6415	9671	11273	108
Sabalan	16950	12110	9576	6614	9771	11004	105
Bartali	15625	12334	8937	6416	10620	10786	103
Agriton	—	—	—	7087	10408	8748	101*
Bartolini	15826	12278	10501	5242	8552	10480	100
Barzini	15553	10165	10180	5980	10321	10440	100
Maris Ledger	**14252**	**11892**	**8074**	**7218**	**10783**	**10444**	**100**
Barextra	—	—	7502	7128	11123	8584	99*
Barverdi	14531	10136	10669	5941	9950	10245	98
Lemtal	16100	11530	7697	6236	9333	10179	97
Meribel	—	—	9998	5746	9023	8256	95*
Bellum	—	—	9900	5799	8464	8054	93*
Bartissimo	14150	11428	6491	5631	8900	9320	89
Crema	—	9102	6963	5618	10500	8046	85*
c.v.	n/a	n/a	53.9	7.4	12.3		
lsd	n/a	n/a	—	662	1723		

* Percentage based on mean of Maris Ledger from years the line was in the trial

Table 4. Westerwolds ryegrass variety trial total forage (2 cuts) production (kg/ha) at Melfort 1996-99

Variety	1996 yield	1997 yield	1998 yield	1999 yield	1996-99 Mean Yld	% Aubade
Barwoltra	16690	11012	10642	7925	11567	110
Barspectra	15959	11095	10387	7609	11263	108
Agraco	17755	10121	8176	8162	11054	106
SW WWR9016	15757	9058	10471	8034	10830	103
Barcimatra	---	---	10857	7475	9166	103*
Magnum	---	---	10476	7749	9113	103*
Barturbo	---	---	9904	7968	8936	101*
Aubade	**15290**	**8832**	**9755**	**8026**	**10476**	**100**
Baroldi	---	---	8886	6959	7923	89*
Max	---	---	9469	5996	7733	87*
Andrea	---	---	7886	7241	7564	85*
Agrihilton	---	---	6947	7277	7112	80*
c.v.	n/a	n/a	50.3	8.5		
lsd	n/a			926		

* Percentage based on mean of Aubade from 1998 and 1999 only

Table 5. Forage yields (kg/ha) of ryegrass lines at Saskatoon - 1999

Variety	Jul-99 Cut 1	9-Sep-99 Cut 2	Total	% of Aubade	% of Maris Ledger	Fall Greeness
Aubade	4681	3828	8510	100	181	2.0
S-9463 WwRG-OP	4034	3384	7418	87	158	2.9
S-9459 WwRG-PC	3779	3011	6790	80	144	3.3
S-9458 IRG-PC	3288	2510	5798	68	123	3.8
Maris Ledger	2232	2478	4710	55	100	4.0
Mean	**3603**	**3042**	**6645**			
CV %	9	12	8			
F-Value	33.3**	10.7**	30.5**			
LSD (0.05)	490	544	816			

Table 6. Forage yields (kg/ha) of ryegrass lines at Saskatoon - 2000

VARIETY	Type	CUT 1 9-Aug-00	CUT 2 25-Sep-00	TOTAL	% of AUBADE
S9463	West. - Sel.	5636	2123	7760	104
AUBADE	West. - Check	5255	2215	7470	100
S9479	West. - Sel.	5245	2095	7341	98
S9459 GH	West. - Sel.	5474	1857	7330	98
S9459 FLD	West. - Sel.	5071	2003	7074	95
MARIS LEDGER	Italian - Check	4475	1706	6181	83
S9480	Italian - Sel.	4605	1364	5969	80
MEAN		5064	1863	6927	
CV(%)		22	19	20	
LSD(0.05)		1666	521	1984	

Table 7. Forage yields (kg/ha) of westerwolds ryegrass lines at Melfort - 2000

Line	Yield	% Aubade
S9479	7640	120
S9459	6610	104
Aubade	6360	100
C.V.	16.6	
LSD	2310	

Table 8. Forage quality (% crude protein, ADF and NDF) of ryegrass lines at Saskatoon 2000

		Cut 1 (Aug 2)			Cut 2 (Sept 22)			Mean		
Cultivar	Type	CP	NDF	ADF	CP	NDF	ADF	CP	NDF	ADF
S9480	Italian - sel.	19.56	41.08	27.30	18.86	31.50	19.89	19.21	36.28	23.59
Maris Ledger	Italian - chk	19.27	38.98	24.92	18.15	34.66	20.20	18.71	36.82	22.56
S9459GH	West. - sel.	18.82	42.27	27.57	17.09	35.99	21.90	17.95	39.13	24.74
S9479	West. - sel.	17.66	44.59	29.53	14.96	37.35	24.44	16.31	40.97	26.99
S9463	West. - sel.	17.05	45.46	29.67	15.24	39.02	25.08	16.14	42.24	27.38
S9459F	West. - sel.	13.91	49.10	31.00	15.17	40.07	26.30	14.54	44.58	28.65
Aubade	West. - check	14.95	47.90	31.67	11.91	47.86	31.36	13.43	47.88	31.52
Mean		16.94	44.90	29.42	15.61	38.04	24.42	16.27	41.47	26.92
F value		2.68 *	7.17 **	7.14 **	2.11NS	7.79 **	15.76 **	4.28 **	14.15 **	26.79 **
LSD		4.10	3.52	2.34	4.72	5.05	2.80	3.11	3.51	2.34

Table 9. LT 50's of Norlea and Catalina perennial ryegrass seeded on five dates in 1998.

Variety	Seeding Date	Sampling 19-Oct	6-Nov	6-Nov *
Norlea	Spring	-13	<-13	<-13
	1-Aug	-13	<-13	<-13
	15-Aug	-13	<-13	<-13
	30-Aug	-11	<-13	<-13
	15-Sep	-11	-11	-11
Catalina	Spring	-11	<-13	<-13
	1-Aug	-13	<-13	<-13
	15-Aug	-13	<-13	<-13
	30-Aug	-11	-13	<-13
	15-Sep	-9	-7	-3

* Plants stored at -2 until Dec. 15.

Table 10. LT 50's of Norlea and Catalina perennial ryegrass seeded on five dates in 1999.

Variety	Seeding Date	Sampling 02 Nov	17 Nov	17 Nov*
Norlea	Spring	-9	<-13	-7
	05-Aug	<-13	<-13	-13
	16-Aug	<-13	<-13	-13
	30-Aug	-9	<-13	-9
	13-Sep	-5	<-13	-7
Catalina	Spring	<-13	<-13	-7
	05-Aug	<-13	<-13	-13
	16-Aug	<-13	<-13	-13
	30-Aug	<-13	<-13	-7
	13-Aug	-5	-13	-7

* Plants stored at -2 until Dec. 17.

Table 11. 1998 Crested Wheatgrass Top Cross Nursery - Kirk x S9240 - 1999 data

Line	13-Jul DMY (kg/ha) Cut 1 (n=3)	19-Sep DMY (kg/ha) Cut 2 (n=3)	DMY (kg/ha) Total '99	% of Kirk	% of S-9240 J
106-15	3832	2216	6048	113	131
105-07	3847	2198	6045	113	131
103-29	3724	2054	5778	108	125
105-12	3844	1880	5724	107	124
102-23	3841	1980	5621	105	122
101-07	3551	1922	5473	102	119
Kirk	**3537**	**1816**	**5353**	**100**	**116**
101-12	3050	2224	5274	99	114
106-01	3272	1955	5227	98	113
106-14	3233	1915	5148	96	112
101-05	3033	1636	4669	87	101
106-45	3237	1371	4608	86	100
S-9240 J	**3121**	**1485**	**4606**	**86**	**100**
103-03	2830	1771	4600	86	100
105-18	3034	1539	4572	85	99
104-21	2662	1898	4560	85	99
101-34	3049	1460	4509	84	98
103-34	2455	1706	4160	78	90
102-27	2560	1536	4096	77	89
103-02	2552	1503	4055	76	88
104-09	1355	769	2125	40	46
Mean	**3115**	**1754**	**4869**		
CV %	22	18	17		
F-value	2.25*	3.55**	3.51**		
LSD $_{(0.05)}$	1136	530	1352		

Table 12. 1998 Crested Wheatgrass Top Cross Nursery - Kirk x S9240 - 2000 data

LINE	Mean Height (cm)	Adjusted Seed Yield (kg/ha)	% OF KIRK
106-05	131	422	114
102-23	94	389	105
105-07	101	382	103
101-07	83	369	100
KIRK	**84**	**369**	**100**
104-44	103	352	95
105-32	92	349	95
106-01	103	347	94
106-19	118	339	92
106-12	121	337	91
101-12	88	314	85
103-29	97	305	83
103-34	94	305	83
103-19	107	303	82
106-14	104	302	82
104-21	109	300	81
103-03	105	299	81
103-40	95	293	79
106-15	109	291	79
S-9240J	89	288	78
101-05	79	288	78
101-20	92	274	74
105-18	101	271	73
101-15	92	268	72
102-27	96	263	71
106-45	91	260	70
101-29	76	247	67
105-12	105	246	67
104-38	109	246	67
102-37	91	240	65
102-04	98	235	64
103-23	105	235	64
101-34	94	227	61
101-24	100	204	55
101-38	93	204	55
103-02	98	200	54
104-09	90	109	29
MEAN	97.7	291.7	
CV(%)	15.7	27.4	
LSD(0.05)	24.9	129.9	

Table 13. Quality analysis of Kirk x S9240 crested wheatgrass crosses - 1999

Sampled at full heading

Selection	% Protein	% NDF	% ADF
101-15	17.3	56.8	31.1
102-27	17.2	57.3	32.0
105-32	16.6	55.6	29.8
104-09	16.6	57.5	31.6
102-04	16.2	58.4	32.4
103-23	16.2	57.0	32.3
106-15	16.1	58.5	33.4
101-20	16.0	56.7	32.8
104-21	15.9	57.6	32.7
101-29	15.8	60.7	33.9
103-02	15.8	57.2	31.9
S9240J	15.7	61.6	35.8
103-19	15.7	57.3	33.0
106-14	15.6	55.1	31.4
101-05	15.6	58.8	33.4
106-45	15.4	63.0	36.2
103-34	15.4	57.5	31.3
105-18	15.3	57.6	33.4
102-23	15.3	58.1	33.8
101-07	15.3	60.9	34.9
104-38	15.2	59.0	33.5
102-37	15.1	59.4	34.2
106-12	15.0	59.4	33.3
101-38	15.0	61.0	35.9
103-29	14.6	59.5	34.4
105-12	14.5	59.8	34.3
104-44	14.5	58.8	33.0
103-03	14.4	59.6	33.7
106-01	14.3	62.1	35.7
101-34	14.2	55.3	31.8
106-19	14.0	62.1	35.9
101-12	14.0	58.8	34.5
105-07	14.0	58.7	33.1
101-24	14.0	59.4	33.2
Kirk	**13.7**	**61.6**	**34.1**
103-40	12.6	63.6	37.5
106-05	12.5	59.3	35.0
Average	15.13	58.91	33.5
F value	0.87 NS	1.01 NS	1.15 NS
LSD	3.45	5.92	4.22

Table 14. Quality analysis of Kirk x S9240 crested wheatgrass crosses - 2000

Sampled June 26, 2000 (full heading)

Selection	% Protein	% NDF	% ADF
106-45	15.49	51.34	29.91
101-15	15.12	51.09	31.48
101-38	15.11	51.87	33.75
103-19	14.60	51.85	31.82
101-12	14.26	49.63	30.41
102-23	14.12	51.04	31.66
105-07	13.54	52.32	31.70
101-05	13.45	49.13	30.36
105-12	13.32	50.70	31.12
106-19	13.04	50.76	30.87
106-05	13.02	55.31	34.12
103-03	13.02	48.88	30.25
105-18	12.80	53.24	32.83
101-20	12.68	49.43	30.12
106-15	12.67	53.24	33.82
104-21	12.61	54.14	32.09
101-24	12.59	52.94	34.20
103-02	12.42	52.93	32.10
104-44	12.39	52.41	31.43
104-09	12.30	49.97	29.20
103-34	12.27	53.40	34.25
S9240J	12.24	53.54	32.50
103-29	12.21	52.12	32.07
102-04	12.16	51.48	31.96
103-23	12.07	51.67	30.78
103-40	11.81	51.37	30.02
Kirk	**11.29**	**52.66**	**30.83**
102-27	11.24	53.16	30.37
101-07	11.19	52.46	31.93
104-38	11.08	54.59	35.75
106-14	10.59	51.44	32.15
106-12	8.89	50.90	33.44
106-01	8.78	54.27	30.62
101-34	8.64	53.57	33.14
Mean	**12.39**	**52.03**	**31.94**
F value	**1.15 NS**	**1.26 NS**	**1.44 NS**
LSD (.05)			

Table 15. Forage yields of miscellaneous crested wheatgrass lines related to Kirk and S9240 - 199

Code	Selection	Yield (kg/ha) 13-Jul-99 Cut 1	16-Sep-99 Cut 2	1999 Total	Two-Year Mean	Height 29-Jun-99 (cm)	Two-Year Mean
10	107	5029	1815	6844	5022	97	92
7	**Kirk breeder- check**	**4640**	**1709**	**6349**	**4913**	**93**	**91**
8	105-24	4992	1699	6691	4875	98	92
9	106-33	4942	1857	6799	4819	106	96
4	106-40	4376	1910	6286	4705	100	92
11	105	4204	1747	5951	4514	102	94
12	S-9240 (96)	4932	1669	6601	4457	105	96
6	110	4001	1933	5934	4426	96	90
3	106-31	3913	1767	5680	4176	105	95
5	106-4	3618	1796	5415	3948	102	93
1	106	3620	1758	5378	3803	98	89
2	105-6	2063	2412	4475	3645	95	93
	Mean	4388	1787	6175	4514	100	93
	CV%	17	14	10	9	5	5
	F-Value	1.11	0.23	1.44	1.86	1.32	0.49
	LSD	ns	ns	ns	ns	ns	ns

Table 16. Seed yields of miscellaneous crested wheatgrass lines related to Kirk and S9240 - 2000

SELECTION	Height (cm) 01-Aug-00	Seed Yield (kg/ha) 17-Aug-00	% Kirk
106-33	93	396	149
106-31	97	305	115
Kirk breeder- check	**85**	**265**	**100**
106-40	89	257	97
S-9240 (96)	92	240	91
105-24	87	236	89
107	90	234	88
110	86	223	84
106	91	215	81
105-6	87	206	78
106-4	98	181	68
105	91	176	66
Mean		91	248
CV%		7.2	12.8
F-Value		0.8	6.8
LSD		14.5	70.7

Table 17. Quality analysis of miscellaneous crested wheatgrass lines related to Kirk and S9240 - 2000 samples

Source	% Protein	% NDF	% ADF
106-40	18.1	48.4	30.5
S9240 (96)	17.9	53.8	32.6
106-4	17.9	50.4	32.3
105-6	17.3	50.3	31.2
110 (Kirk 92)	17.1	51.2	31.8
Kirk Breeder	**16.8**	**49.2**	**30.9**
105-24	16.5	51.2	31.6
107 (Kirk 88)	15.8	51.8	32.1
106-33	15.5	53.7	32.9
106-31	15.1	50.1	31.1
106	14.5	53.6	32.8
105	14.5	52.6	31.8
Mean	**16.4**	**51.4**	**31.8**